# A MOBILE BUSINESS PROCESS DEPLOYMENT FRAMEWORK FOR DEVICE INDEPENDENCE AND CONTEXT-AWARE ENVIRONMENTS

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Keywords: Business processes, Location aware, device independence, context-aware.

Abstract: Deployment of a business process to mobile devices in different context and in a device independence environment is a challenging task. The desirable is that a Business Process could be deployed to any mobile device in any location or environment the user operates. One obstacle in business process deployment on mobile devices is the rapid changes in mobile technologies. In this research we have developed and implemented a mobile business process deployment framework that caters for both device independence and context-aware environments. In this paper the focus is on how device independence and context-awareness can be integrated for mobile business processes deployment.

## 1 INTRODUCTION

The companies recently have been paying a great deal of attention to the potential of mobile communication technologies to redefine and extend the world of traditional E-Business by making its applications more available to the mobile users. According to (Swaminathan and S.R.Tayur 2003), E-business is defined as "a business process that uses internet or other electronic medium as a channel to complete business transactions".

Mobile Business is often described as the successor of electronic business and defined as the subset of it (Adam, Chikova et al. 2005). It is assumed that any business operations performed by desktop computer can also be performed via wireless network. However mobile technology offers additional possibilities that are unique to the wireless world and cannot be performed via fixed network. For example, providing the mobile users with the services of location aware and context-aware applications which cannot be performed with a fixed internet connection (Zhang, Archer et al. 2003). Mobile business can be defined as the exchange of goods, services, and information using mobile devices (Paavilainen 2002) .

Mobile Services are usually characterized by mobility; reach-ability, localization, and identification (Kaasinen 2003) (Siau and Shen 2003). Mobility is the central distinguishing feature of mobile technology. As mobile devices constantly accompany their users, people can receive and send data regardless of place and time. They can also be reached by people at all times. This feature is especially useful to logistic and supply chain companies that regularly need to reach their mobile workforce to allocate various tasks to them.

The success of the recent applications is based not only on new technology, but rather on its proper use (Liang and Wei 2004). Wireless applications would be advantageous only when they can be useful to their end users (Kalakota and Robinson 2001). Mobile business value proposition originate from the fusion of the wireless technology with already available electronic business applications. On the other hand, the unique features of mobile business – mobility, localization give rise to emergence of completely new applications and business models.

### 1.1 Mobile Business Processes

according to Davenport (Davenport 1992) a business process can be defined as "a specific ordering of work activities across time and place, with a beginning, an end, and clearly identified



Torabi T., Ali S. and Ali H. (2008).
A MOBILE BUSINESS PROCESS DEPLOYMENT FRAMEWORK FOR DEVICE INDEPENDENCE AND CONTEXT-AWARE ENVIRONMENTS.
In *Proceedings of the International Conference on e-Business*, pages 209-216
DOI: 10.5220/0001914002090216

inputs and outputs: a structure for action." The business profit depends on efficient delivery of goods and services controlled by business process (Ali, Torabi et al. 2006) (Ali, Soh et al. 2005). So there is a need for the companies to make use of the technologies to make their product more profitable and their services more efficient.

Many companies have been able to make their traditional business processes into mobile business processes. "*Mobile Business Process*" is a business process, when a place of execution of an activity can be different in different instances of the business process or places can change during the execution of an activity (Ritz and Stender 2003) (Berger, Bouzid et al. 2003). Mobile Business Processes can be based on these three assumptions:

- "Uncertainty of Location".
- "Uncertainty of Location" is externally determined, and
- A corporation with external resources is needed in the execution of the process.

## 1.2 Context-Aware Mobile Applications

Context means situational information, or as (Barkhuss and Dey 2003) states: "Context is any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and the application themselves."

Context-aware is a concept where the applications can discover and take advantage of contextual information such as user location, time of day, nearby people, devices, and user activity.

An example of context-aware applications is the scenario in which a consumer makes use of the mobile technologies in retail grocery supply chain through mobile shopping of electronically referenced grocery products. This kind of application is also beneficial to retailers, who by knowing the exact location of the consumer can allocate the workforce more accordingly and efficiently, and can avoid out-of-stocks (Hakkila and Mantyiarvi 2005) (Koolwaaij and Strating 2003).

## 1.3 Device Independence

In today's world of rapidly changing technologies and the rise in the use of mobile devices has created a need for content adaptation. According to one of the authors (Mikhalenki 2004), the goal of device independence is to develop ways for future web content and applications to be authored, generated, or adapted for a better user experience when delivered via many device types.

Currently many companies typically design web applications for desktop browsers. And adaptation of this kind of web site for small display is effectively impossible and the companies creating a parallel site for these devices is also impractical. To solve this problem, the device-independent approach is used to support different devices without the high cost.

Device Independence technologies can be divided into three different categories namely: - intermediate, client-side and server-side (Butler, Giannetti et al. 2002).

Intermediate approach can offer limited adaptation to the content delivery. This approach gives data-enabled phones access to web sites either omitting server's full resolution colour images or changing it to the low resolution depending on the device display capabilities (Hwang, Kim et al. 2003) (Butler, Giannetti et al. 2002).

In the client-side approach the content adaptation can occur on the device itself. The advantage for this approach is that the adaptation code has direct access to the device capabilities (Butler, Giannetti et al. 2002).

Server-side content adaptation approach offers maximum control over the delivered content including the ability to change content, navigation and style. In this approach the server is assumed to have sufficient information about the delivery context, including the delivery device capabilities.

Using device independence approach the content integrators do not need to develop content for every single device, where the content can be delivered to different devices without accumulating more resources and effort.

In the next sub-section we will discuss different deployment methodologies and we will discuss our approach in mobile business process deployment.

## 1.4 Deployment

In terms of technology, the word "deployment" means "Installing, setting up, testing, and execution" (Ali, Torabi et al. 2006). Therefore, deployment can be interpreted as a general process that must be customized according to specific requirements or characteristics.

Deployment of software, applications or a process is a complex task which covers all the

activities from the end of the development itself to installation and maintenance of the application on the consumer devices. In (Richman 2001) the authors have compared different types of deployment techniques in terms of their scale, complexity, expressiveness, and barriers to first use. The deployment solutions being handled by these implementation techniques: manual, script, language, and model-based deployment.

The automation of application or service deployment improves correctness, speed and documentation but, as different companies have experienced, it comes at an increased cost in development time and a steeper administrators' learning curve.

According to recent research, business processes are deployed through XML web services. Web services can be considered as the emerging distributed middleware technology that uses a simple XML-based protocol to allow applications to exchange data across the web (Zhang, Zhang et al. 2004; Hammadi, Ali et al. 2006). At the core of the Web Service is the Simple Object Access Protocol (SOAP) an XML-based communication protocol for interacting with Web Services. The SOAP specification includes syntax to define messages, encode or serialize rules for data exchange and conventions for representing RPCs (Austaller, Kangsharju et al. 2004) .

WSDL is used for describing the services available. It describes where the service is located, what operations are supported and the format of the messages to be exchanged based on how the service is invoked (Gokhale, Kumar et al. 2002; Austaller, Kangsharju et al. 2004). On the other hand Business Process Execution Language (BPEL) is the language that is used to implement business processes in Web Services. It defines a notation for specifying business process behavior based on Web Services (IBM, Systems et al. 2002).

Certain technologies and models have been presented in recent years for the deployment of services and applications using mobile technology. One of the technologies being used recently by the companies for the deployment of services is over-the-air (OTA) deployment. OTA is becoming increasingly important to support. OTA delivery enables easy deployment and upgrades to the applications, thereby reducing the disrupting effect which installation of new applications and upgrades may have on mobile users (Taconet, Putrycz et al. 2003) (Fjellheim 2006).

Another kind of deployment technique is "static deployment" where the user connects to the site of the application server through its mobile and then subscribes to a download operation. Then the user receives an SMS containing instructions for downloading and installing the application.

The framework known as Smart Deployment Infrastructure (SDI) is designed to facilitate the installation of large distributed applications for any kind of user terminal. This framework is also presented for the context-aware deployment of applications to the mobile users (Taconet, Putrycz et al. 2003). The framework is implemented with middleware technologies like CORBA and SOAP which facilitates the development of large scale distributed applications. SDI offers automatic deployment of multi-component applications and provides a deployment solution to customize installation and to adapt to device capabilities (Courtney 2000; Taconet, Putrycz et al. 2003).
In the next section we will present a framework for mobile business process deployment. The framework caters for deployment of a process in a device independence and context-aware environment.

## 2 THE FRAMEWORK

In this section we present a novel framework for business process deployment in a mobile environment taking into account the context of the user and specification of the device to be used. The overview of the architecture is shown in Figure 1.

The framework proposed consists of five different components:

- Deployment component
- Process specification component
- Device Specification component
- Context-Aware component
- Mobile Interface component

The "***deployment component***" is the main component of the framework. This framework consists of two layers namely *Composition Layer* and *Deployment Layer*. The work for the composition layer is to compose a selected Business Process, setting the context of the deployment and customizing the process according to the device being used in the "Mobile Environment". Where the deployment layer activates the customized business process to the Mobile Environment.

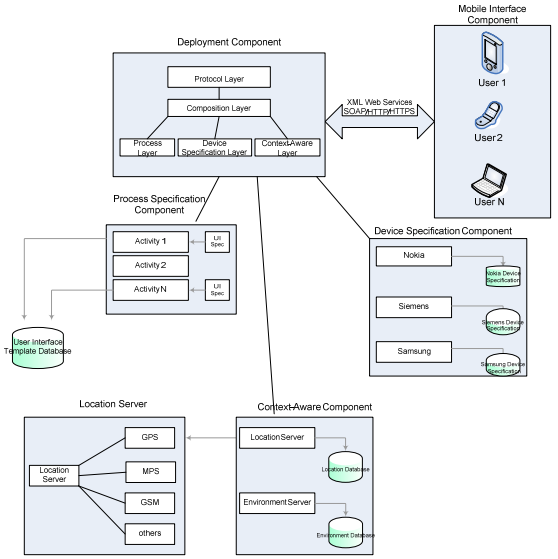


Figure 1: Device Independence & Context-aware mobile process deployment framework.

The second component in this framework is "**process specification component**". This is a traditional Business Process component consisting of activities, resources and user interfaces. User Interfaces are stored as XML documents in the UI Database associated with process specification component.

**"Device Specification component**" is a typical component. It consists of different hardware configurations, screen resolution settings and other features for the mobile devices being currently used in the Mobile Environment.

**"Context-Aware component"** consists of many parameters but in our Context-Aware component, we only consider two parameters *"Location and Environment"*. The location of the *Mobile User* is determined using different technologies like GPS, GSM, or MPS as shown in location server defined in our architecture. The "Location Database" is used to store all the locations of the users and later can be used in process deployment.

**"Mobile Interface component**" consists of the N number of users using N number of mobile devices. The Mobile devices being used can be pocket pc's, smart phone's or PDA's etc.

In the rest of this section we will present the Framework Design and the System Architecture. The three-tier system architecture best shows the interaction between the components and communication between the three tiers.

## 2.1 The Framework Design

This section will focus on the Object-Oriented Design for the proposed Mobile Business Process Deployment Framework.

We will start our design with the "High Level Component Diagram" as presented in Figure 2.

Our Object Oriented design is generic, flexible, scalable, reusable, and it provides the flexibility to coordinate, coordinate, and synchronize between components and process automation.

This component diagram shows the system functionality through a high level of abstraction. For our design there are nine active components.

In this section we will be present a brief description of each of the components. We will briefly discuss the functionalities and properties that each of the components possesses then in the next section we will discuss each component in detail with the help of a class diagram. The brief explanation of each of the components is as follows:

**Mapping Engine:** - This component is to take care of mapping between different protocols. All the functionalities like displaying simple map, Geo-coding, Reverse Geo-coding and routing would be done by this component.

**Process Specification:** - This is a traditional Business Process component consisting of activities, resources and related user interfaces. All the specifications would take place in this component. The specification for the Business Process along with its activities, resources and user interfaces are stored in process database.


Figure 2: High level component diagram.

**Device Specification:** - It consists of different hardware configurations, screen resolution settings and other features for the mobile devices being currently used in the Mobile Environment. In the framework these would be stored as an XML documents and would be used at the time of deployment. Device database is used to store all the device specification for different mobile devices.

**Context-Aware:** - Consists of many parameters including "Location and Environment" parameters. In this component we show how the location and environment parameter can be determined using different positioning and sensor technologies. Context database is using to store the context information of the user in the mobile environment.

**Deployment:** - This is the major component of the framework. This component is where the actual deployment would take place. All the components would be integrated and coordinated before deploying to the mobile environment. All the Protocols and Web Services technologies would also reside in this component.

**XML Parsing Component:** - All the XML parsing of the incoming responses, XML documents stored for Process Specification, Context and Device Specification is carried out by this component.

### 2.1.1 Mapping Engine

The purpose of the mapping engine is to provide the framework with the maps if required during deployment. The maps are really important if one wants to show the user its location that in our case one of the parameters of the context information. The class diagram for the component is shown in Figure 3.

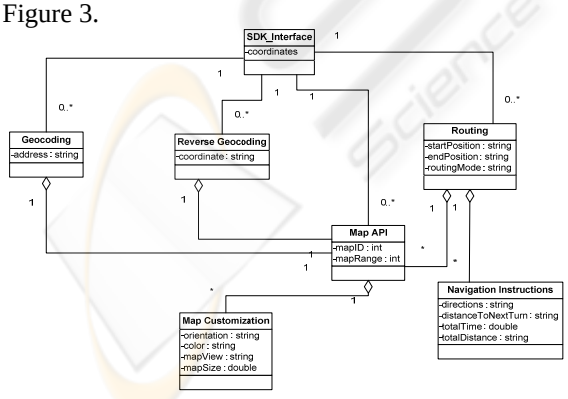


Figure 3: Mapping Engine.

Mapping Engine is adopted from a Location Based Services Company, iGoPlus, this exercise. As can be seen from the class diagram above, there is a SDK Interface that links the application with the mapping engine

Through this engine our framework would be able to do the following functionalities:

- Display simple map with centerOnAddress or CenterOnPositon. Where the map would be centered either by latitude longitude position or by address.
- Show Geocoded address on the Map.
- Do Reverse Geocoding and show the position of the points on the map.
- Display the route between two points on the map. This also includes displaying the Text Instructions required in navigating from start to end position.
- Do the map customization in terms of orientation, color, mapView and size.

### 2.1.2 Process Specification

This component takes care of the Business Process Specification along with its activities and resources. A Business Process can have many activities and each can have different resources.

User interfaces are attached to each subsequent activity. Not every activity may have a user interface. User interfaces are associated to activities during business process specification. The class diagram for Process Specification is shown in Figure 4.

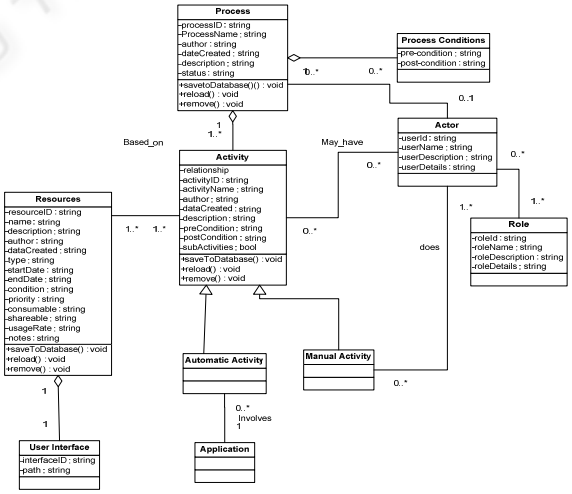


Figure 4: Process specification.

A Business Process may have number of activities and each activity has some resources at its disposal. Among others other characteristics of resources includes whether or not they are

consumable or sharable resources. User interface specification is an important part of this component. In our framework we are assuming that user interfaces would not be specified but only referenced. Its attributes include id and path where user interfaces are stored. It should be noted that not all activities would have user interfaces attached to it.

The Process Specification is stored in the database. It can be seen from the diagram that there is one main super class "Database Management" which has all the subclasses from it, which are used in the system. The class "Database Management" contains all the attributes and the operations common to all the classes.

### 2.1.3 Device Specification

Having discussed the design for Mapping Engine and Process Specification, in this section we will present the design for Device Specification. Device Specification is stored as an XML document in the database. Device Specification consists of software and hardware specification. Other components interact with this component through Device Interface. The design of the device specification of the framework is shown in Figure 5.

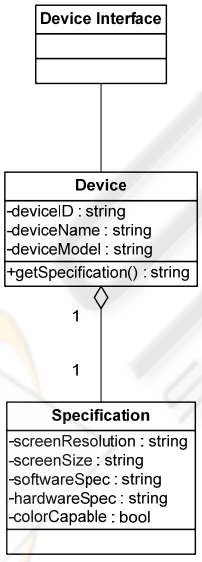


Figure 5: Device specification.

As can be seen from the diagram, the framework interacts with the device specification component through an interface. One device would have one specification and the specification would have attributes such as screen resolution, screen size, software specification, hardware specification and colour capability.

### 2.1.4 Context-Aware

In this section we present the design for context-aware component. There are many parameters as part of context-aware information, including the location and environment. The contextual information for this component would be stored as XML documents in the database.

The design for this component is based on the working of commercial applications like on-board navigation systems, gadgets or sensors for light or noise. The context parameters, location and environment will be determined as shown in Figure 6.

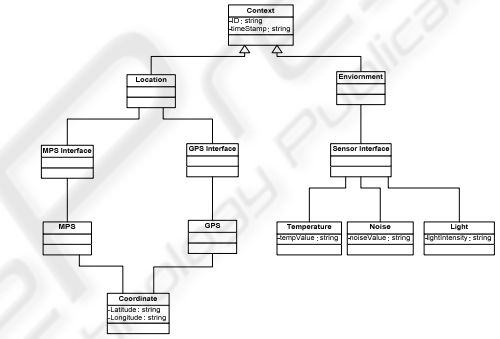


Figure 6: Context-aware component.

The framework will be determining location through two positioning technologies that are MPS and GPS. The position from these two technologies is in the form of Latitude and Longitude. Whereas Environment parameters is determined through sensor interfaces as shown in Figure 6.

### 2.1.5 Deployment

Having specified Business Process, activities and resources, the deployment component brings context information and customized user interfaces together before deploying it to mobile environment. The composition layer coordinates and integrates all three components and the mapping engine component before the protocol layer can deploy it. The design for the deployment component is shown in Figure 7.

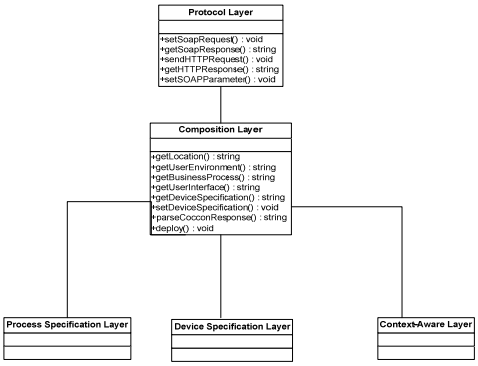


Figure 7: Deployment component.

This component is the backbone for the deployment process. The Composition layer coordinates and integrates all the three components together towards the deployment process. Examples of functions being performed by this layer are as follows:

- getLocation():- Gets the location of the particular user from the Context-Aware Component. The response returned would be in terms of latitude and longitude.
- getDeviceSpecification():-Gets the Device Specification for a particular device from the Device Specification Component.
- setDeviceSpecification():- Sets the Device Specification for a particular mobile device in the Device Specification Component.

A Business Process can be deployed either by HTTP connection or by SOAP commands. The Framework caters for both of these protocols.

## 2.2 System Architecture

The system architecture for the Mobile Business Process Deployment Framework is divided into three main parts client layer, business logic and database layer. The System Architecture is shown in Figure 8.

The client layer or tier interfaces between the system and the user. It consists of a mobile device running on operating system windows CE 5.0. The Business Process is deployed to a mobile device in form of XML document. The communication between client tier and business logic tier is done through XML web services hosted on ASP. Net Web Server.

Apache Cocoon Server is used in the framework to determine the software capabilities of a mobile device from the responses received from the client tier. ASP .Net local Web Server is used to support XML Web Services and Simple Object Access Protocol (SOAP). These technologies set up the communication between the server and the client.

Contextual Information and specifications for mobile devices are also stored as XML documents in the Mysql Database.

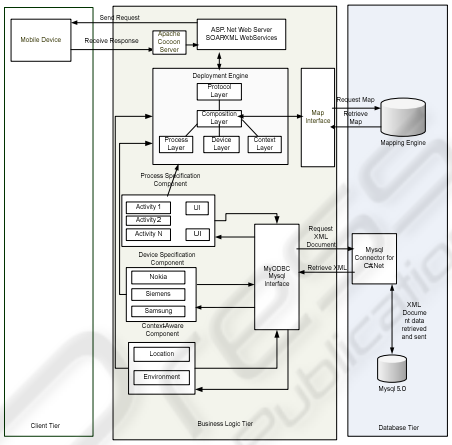


Figure 8: Three tier architecture.

Deployment Engine Component consists of two layers Composition Layer and Protocol Layer. The responsibility for the composition layer is to compose a selected Business Process, setting the context of the deployment and customizing the business process according to the device being used. The protocol layer would set protocols for the deployment like setting up parameter for SOAP commands and setting up HTTP connections.

The database layer consists of database and Mapping Engine. For communication between Business Logic Tier and Mysql, there is MyODBC Interface that takes the request from the server and sends it to database.

# 3 CONCLUSIONS

In this paper we have discussed deployment of a business process to a mobile device in a chosen context and in a device independence environment. A Business Process can be deployed to any mobile device in any location or environment the user may be. This framework helps companies and developers to deploy same business processes to different mobile devices without any software or user interface configuration. Much research has been done in the field of context-aware and device

independence, our contribution to this research is to bring these aspects together and design a framework that can bring more flexibility to the provider and the consumer.

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